

CLAIMS

What is claimed is:

- 1 1. An apparatus comprising:
2 a pre-driver coupled to a control circuit to generate pre-driving signals based on
3 control signals provided by the control circuit, the pre-driver having pre-driver power
4 and ground connections;
5 a driver coupled to the pre-driver to generate an output signal based on the pre-
6 driving signals at an output pad, the output signal having a slew rate, the driver having
7 driver power and ground connections; and
8 a low pass filter coupled between the pre-driver and driver power and ground
9 connections to reduce noise at the pre-driver, the low pass filter having a cut-off
10 frequency corresponding to noise frequency.

- 1 2. The apparatus of claim 1 wherein the low pass filter maintains the slew
2 rate.

- 1 3. The apparatus of claim 1 wherein the low pass filter comprises:
2 a resistor connected between the pre-driver and driver power connections, the
3 resistor having a resistance selected according to a pre-determined voltage drop and a
4 current limit of the pre-driver; and
5 a capacitor connected between the pre-driver power and ground connections,
6 the capacitor having a capacitance selected according to the selected resistance and the
7 cut-off frequency.

- 1 4. The apparatus of claim 1 further comprising:
2 a ground resistor coupled between the pre-driver ground and the driver ground
3 to isolate the pre-driver ground from the driver ground.

- 1 5. The apparatus of claim 4 wherein the ground selector has a resistance
2 selected according to a pre-determined voltage drop and a ground current limit.

- 1 6. An apparatus comprising:

2 a plurality of pre-drivers coupled to a control circuit to generate pre-driving
3 signals based on control signals provided by the control circuit, the pre-drivers having
4 pre-driver power and ground connections;

5 a plurality of drivers coupled to the pre-drivers to generate a plurality of output
6 signals based on the pre-driving signals at output pads of an integrated circuit, each of
7 the output signals having a slew rate, the drivers having driver power and ground
8 connections;

9 on-die pre-driver power and ground planes coupled to the pre-driver power and
10 ground connections on die of the integrated circuit, respectively; and

11 on-die driver power and ground planes coupled to the driver power and ground
12 connections on die of the integrated circuit, respectively, the driver power and ground
13 planes being separated from the pre-driver power and ground planes to maintain the
14 slew rate.

1 7. The apparatus of claim 6 wherein the on-die pre-driver power and
2 ground planes are coupled to package pre-driver power and ground planes,
3 respectively, in the package of the integrated circuit.

1 8. The apparatus of claim 7 wherein the on-die driver power and ground
2 planes are coupled to package driver power and ground planes, respectively, in the
3 package of the integrated circuit.

1 9. The apparatus of claim 8 wherein the package pre-driver power plane
2 and the package driver power plane share board power plane on a motherboard
3 containing the integrated circuit.

1 10. The apparatus of claim 8 wherein the package pre-driver ground plane
2 and the package driver ground plane share board ground plane on a motherboard
3 containing the integrated circuit.

1 11. A method comprising:
2 generating pre-driving signals using a pre-driver based on control signals
3 provided by a control circuit, the pre-driver having pre-driver power and ground
4 connections;

5 generating an output signal using a driver based on the pre-driving signals at an
6 output pad, the output signal having a slew rate, the driver having driver power and
7 ground connections; and
8 reducing noise at the pre-driving signals using a low pass filter, the low pass
9 filter having a cut-off frequency corresponding to noise frequency.

1 12. The method of claim 11 wherein reducing the noise comprises
2 maintaining the slew rate.

1 13. The method of claim 11 wherein reducing the noise comprises:
2 providing a resistor connected between the pre-driver and driver power
3 connections, the resistor having a resistance selected according to a pre-determined
4 voltage drop and a current limit of the pre-driver; and
5 providing a capacitor connected between the pre-driver power and ground
6 connections, the capacitor having a capacitance selected according to the selected
7 resistance and the cut-off frequency.

1 14. The method of claim 11 further comprising:
2 isolating the pre-driver ground from the driver ground using a ground resistor.

1 15. The method of claim 14 wherein the ground selector has a resistance
2 selected according to a pre-determined voltage drop and a ground current limit.

1 16. A method comprising:
2 generating pre-driving signals by a plurality of pre-drivers based on control
3 signals provided by a control circuit, the pre-drivers having pre-driver power and
4 ground connections;
5 generating a plurality of output signals by a plurality of drivers based on the
6 pre-driving signals at output pads of an integrated circuit, each of the output signals
7 having a slew rate, the drivers having driver power and ground connections;
8 connecting on-die pre-driver power and ground planes to the pre-driver power
9 and ground connections on die of the integrated circuit, respectively;
10 connecting on-die driver power and ground planes to the driver power and
11 ground connections on die of the integrated circuit, respectively; and

12 separating on-die pre-driver power and ground planes from on-die driver power
13 and ground planes.

1 17. The method of claim 16 further comprising connecting the on-die pre-
2 driver power and ground planes to package pre-driver power and ground planes,
3 respectively, in the package of the integrated circuit.

1 18. The method of claim 17 further comprising connecting the on-die driver
2 power and ground planes to package driver power and ground planes, respectively, in
3 the package of the integrated circuit.

1 19. The method of claim 18 further comprising sharing board power plane
2 on a motherboard containing the integrated circuit by the package pre-driver power
3 plane and the package driver power plane share.

1 20. The method of claim 18 further comprising sharing board ground plane
2 on a motherboard containing the integrated circuit by the package pre-driver ground
3 plane and the package driver ground plane share.

1 21. A device comprising:
2 a package having package power and ground planes and output pins to interface
3 to a board having board power and ground planes;
4 an integrated circuit on a die coupled to the package, the integrated circuit
5 having a buffer circuit, the buffer circuit comprising:
6 a pre-driver coupled to a control circuit to generate pre-driving signals
7 based on control signals provided by the control circuit, the pre-driver
8 having pre-driver power and ground connections,
9 a driver coupled to the pre-driver to generate an output signal based on
10 the pre-driving signals at an output pad, the output signal having a slew
11 rate, the driver having driver power and ground connections, and
12 a low pass filter coupled between the pre-driver and the driver to reduce
13 noise at the pre-driving signals, the low pass filter having a cut-off
14 frequency corresponding to noise frequency.

1 22. The device of claim 21 wherein the low pass filter maintains the slew
2 rate.

1 23. The device of claim 21 wherein the low pass filter comprises:
2 a resistor connected between the pre-driver and driver power connections, the
3 resistor having a resistance selected according to a pre-determined voltage drop and a
4 current limit of the pre-driver; and
5 a capacitor connected between the pre-driver power and ground connections,
6 the capacitor having a capacitance selected according to the selected resistance and the
7 cut-off frequency.

1 24. The device of claim 21 further comprising:
2 a ground resistor coupled between the pre-driver ground and the driver ground
3 to isolate the pre-driver ground from the driver ground.

1 25. The device of claim 24 wherein the ground selector has a resistance
2 selected according to a pre-determined voltage drop and a ground current limit.

1 26. A device comprising:
2 a package having package power and ground connections and output pins to
3 interface to a board having board power and ground planes; and
4 an integrated circuit on a die coupled to the package, the integrated circuit
5 having a buffer circuit, the buffer circuit comprising:
6 a plurality of pre-drivers coupled to a control circuit to generate pre-
7 driving signals based on control signals provided by the control circuit,
8 the pre-drivers having pre-driver power and ground connections,
9 a plurality of drivers coupled to the pre-drivers to generate a plurality of
10 output signals based on the pre-driving signals at output pads of the
11 integrated circuit, each of the output signals having a slew rate, the
12 drivers having driver power and ground connections,
13 on-die pre-driver power and ground planes coupled to the pre-driver
14 power and ground connections on the die of the integrated circuit,
15 respectively, and

16 on-die driver power and ground planes coupled to the driver power and
17 ground connections on the die of the integrated circuit, respectively, the
18 driver power and ground planes being separated from the pre-driver
19 power and ground planes to maintain the slew rate.

1 27. The device of claim 26 wherein the on-die pre-driver power and ground
2 planes are coupled to package pre-driver power and ground planes in the package.

1 28. The device of claim 27 wherein the on-die driver power and ground
2 planes are coupled to package driver power and ground planes, respectively, in the
3 package.

1 29. The device of claim 28 wherein the package pre-driver power plane and
2 the package driver power plane share the board power plane on a motherboard
3 containing the integrated circuit.

1 30. The device of claim 28 wherein the package pre-driver ground
2 plane and the package driver ground plane share the board ground plane on a
3 motherboard containing the integrated circuit.